The Mars 2020 Approach for Assessing Landing Risks for Sites Requiring Terrain Relative Navigation

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IPPW-12 Conference

June 2015

Overview

- Potential sites were ranked scientifically for the M2020 mission

- Many sites are enabled by Terrain Relative Navigation (TRN)

  - MSL-safe ellipse placement can not be reasonably placed near to the areas of scientific interest

  - A sampling schedule of ~1 year is very challenging operationally

- MSL hazard maps lack the resolution required to evaluate the performance of TRN

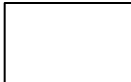- M2020 has modified MSL hazard map generation methods to generate a sufficient hazard resolution
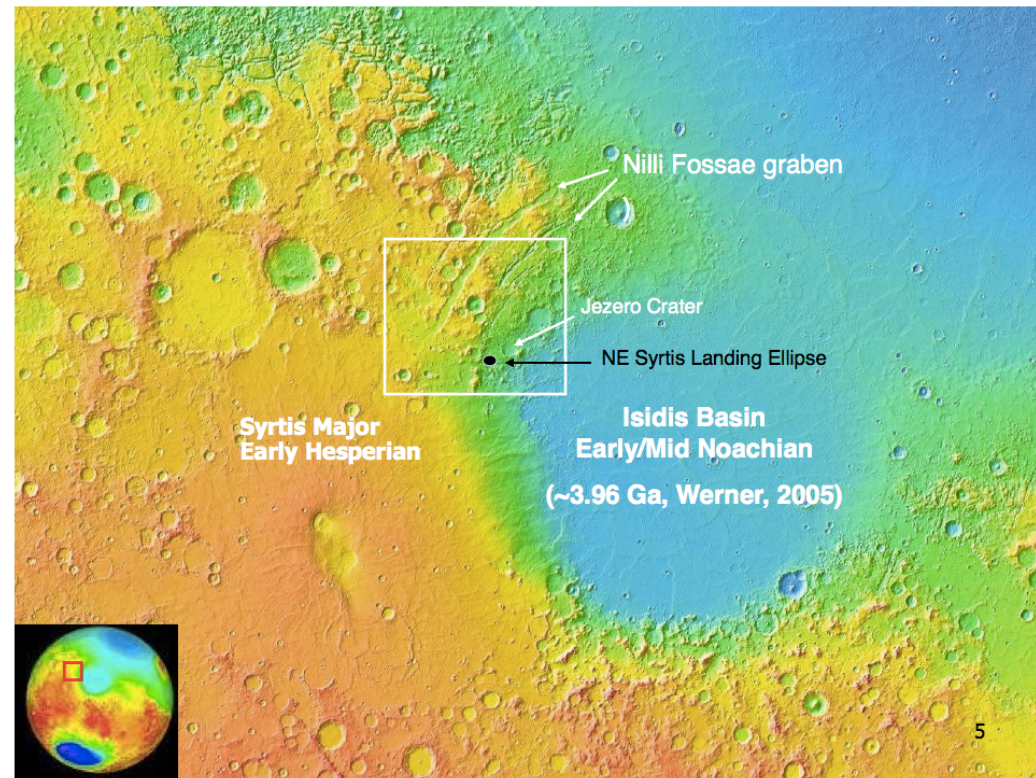
Top-9 Landing Site Locations

Rank	Candidate Landing Site
1	NE Syrtis
2	Nili Fossae
3	Nili Fossae Carbonates
4	Jezero Crater Delta
5	Holden Crater
6	McLaughlin Crater
7	Southwest Melas Basin
8	Mawrth Vallis, MSL Site
9	East Margaritifer Chloride

Site likely requires TRN

Site does not require TRN

Site has both TRN and non-TRN solutions

Nilli Fossae graben

Jezero Crater

NE Syrtis Landing Ellipse

Syrtis Major
Early Hesperian

Isidis Basin
Early/Mid Noachian

(~3.96 Ga, Werner, 2005)

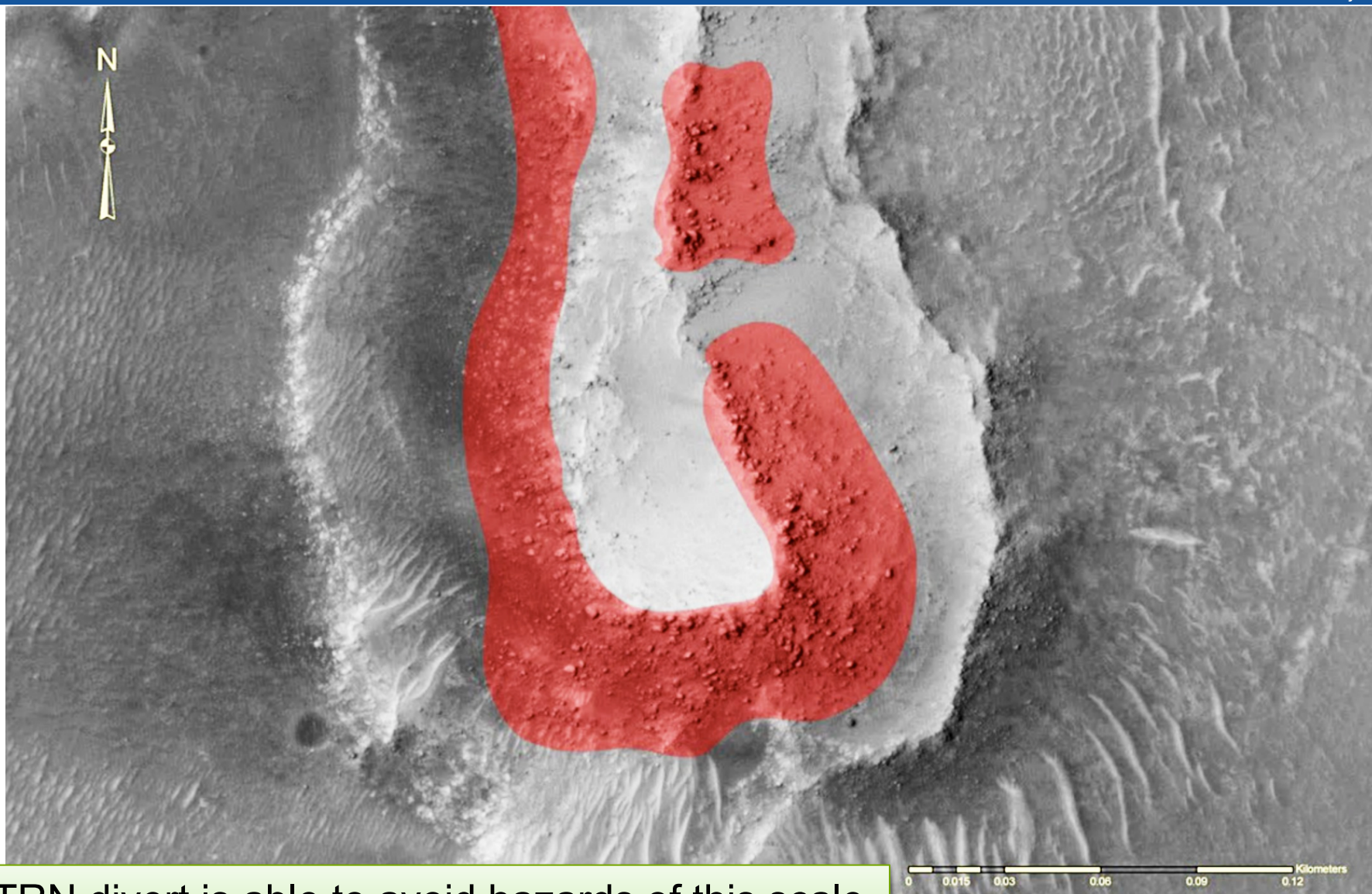Source: JF Mustard, et al., NE Syrtis Presentation, 1st M2020 LSW
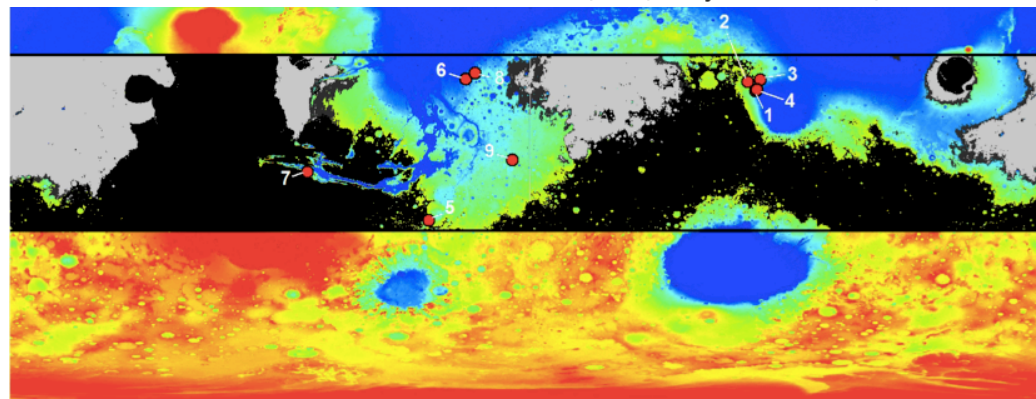
NE Syrtis: Highest Ranked TRN Site

TRN required to divert from the large number of landing hazards at this site

NE Syrtis Scarp/Rock Hazards Zoomed

TRN divert is able to avoid hazards of this scale

- TRN is used to avoid known hazards with a map-relative execution error of a 60m radius.

- The MSL hazard map approach had a locality resolution of 150x150m
  - The distribution information for the TRN execution uncertainty could not effect a MSL-like hazard estimate
  - The divert would cover 2-4 MSL hazard map pixels
  - Down sampling information could hide potentially safe places to land

- The M2020 approach needed to evolve to incorporate more hazard location information
  - Map components will be known at a 30x30m resolution or better.
  - A modified way of estimating the rock distribution led to a locality resolution reduction from 150x150m to 30x30m

The scale of the TRN divert and execution uncertainty requires more accurate maps to correctly estimate its performance

- Touchdown hazard map gathers a mix of locality resolutions
- The hazard source with the greatest uncertainty for MSL was the rock hazard map for smaller rocks

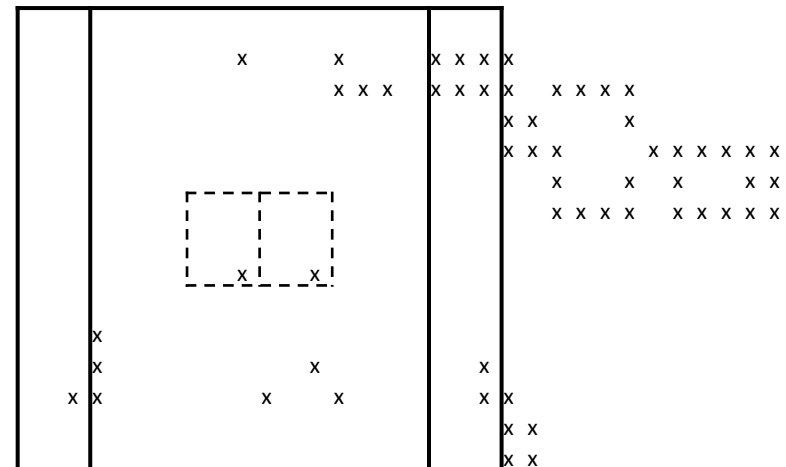| Hazard Source	MSL	M2020	
		>=1.5m dia	**<1.5m dia**
Rock Hazards	150x150m map tiles (tile = an area with a single value)	Direct lat/long identification of rocks currently with an accuracy of <10m (e.g. Jezero was ~4 +/- 2m)	Use 30x30m CFA map tiles (150x150m support)
Radar Spoofing Hazard	150x150m (worst / mean slope recorded from 20x20m DEM)	20x20m (DEM resolution)	
Rover Scale Slope Hazards	150x150m (worst / mean slope recorded from rover scale slopes)	1x1m (rover scale slopes at this 1x1m location)	
Inescapable Hazards	~1x1m	~1x1m	

- Example shows 'x' as rocks
- The MSL approach
  - averages rock contribution into 150x150m bins
  - rock rich bins may still have clear areas that could be used for landing
- The M2020 Approach
  - Still uses the same statistical mechanics as the MSL version
  - the smaller bin in the center of the support tile is assigned the value calculated from the support tile
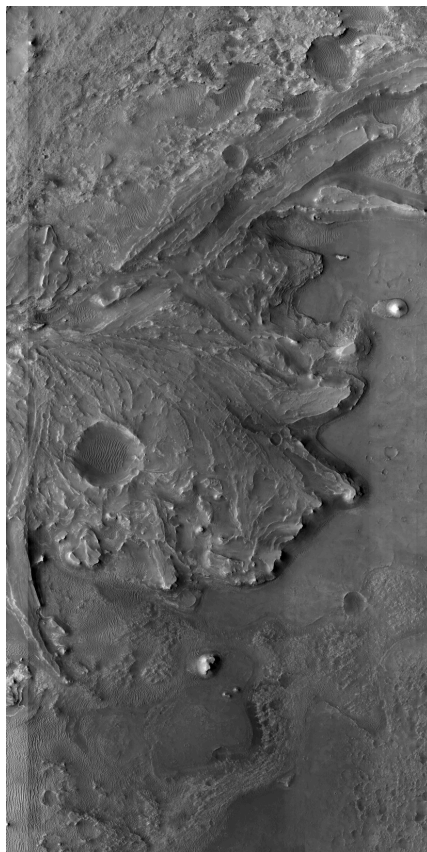 - the support tile exists to have a large enough area for a meaningful statistical sample of rocks
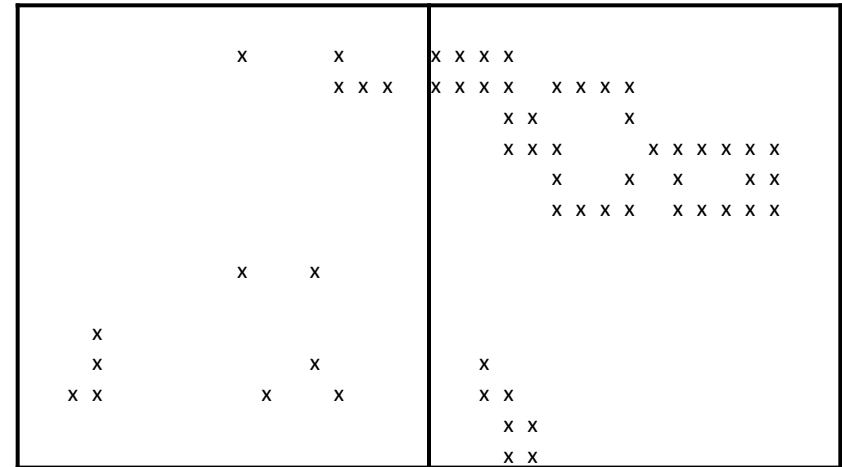
A rolling average approach was shown to enable higher location resolution rock maps

MSL Approach

M2020 Approach

PSP_002387 Rock CFA
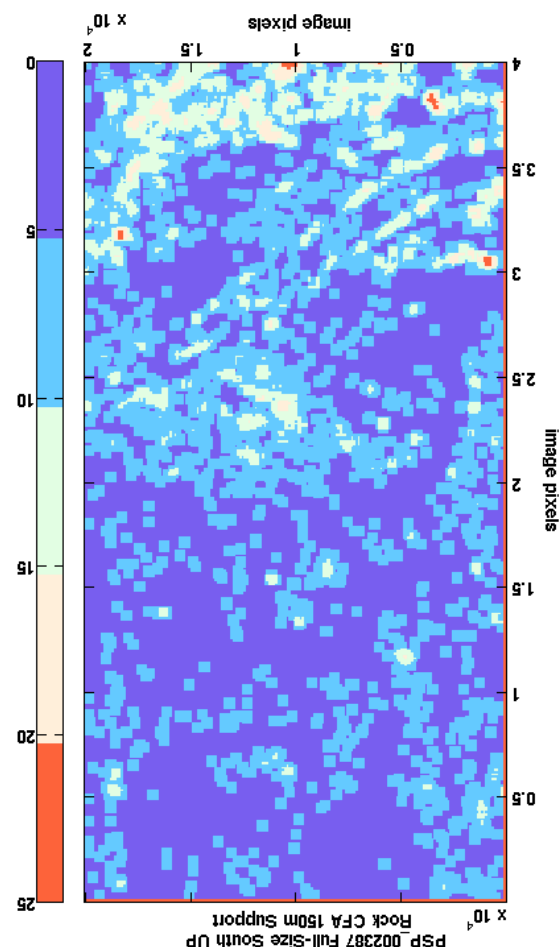150m-tile fit D:[1.5-2.25]   Area<=10%: 0.914

Similar gross features but higher resolution provides far better hazard locality information
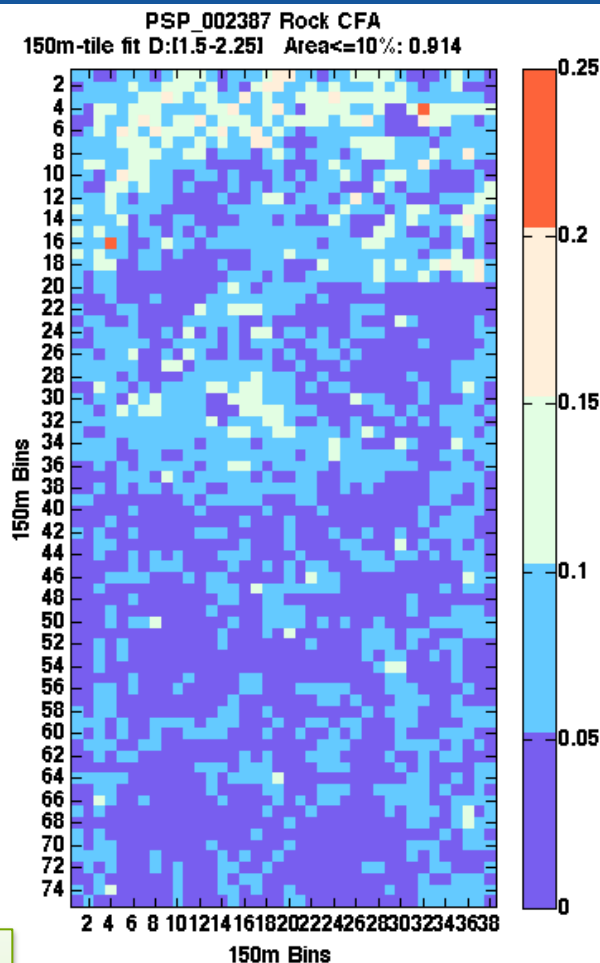
map resolution:150m
CFA support:150m

map resolution:30m
CFA support:150m

Conclusions

- Correctly modeling TRN performance for a site requires an improvement to map fidelity

- MSL hazard maps were kept to the resolution of the component with the most location uncertainty
  - the 150x150m rock CFA map
  - MSL had no reason to push this further

- A new method was used to generate higher resolution CFA maps for M2020

- This method allows for an increase in total map resolution that is sufficient to evaluate TRN